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THE LEATHER BELTING EXCHANGE FOUNDATION
CORNELL UNIVERSITY
ITHACA, N. Y.

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# A Report of an Experiment to Determine the Law of Variation Between the Width and Transmitting Capacity of Leather Belting

by

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The Leather Belting Exchange
Philadelphia, Pa.
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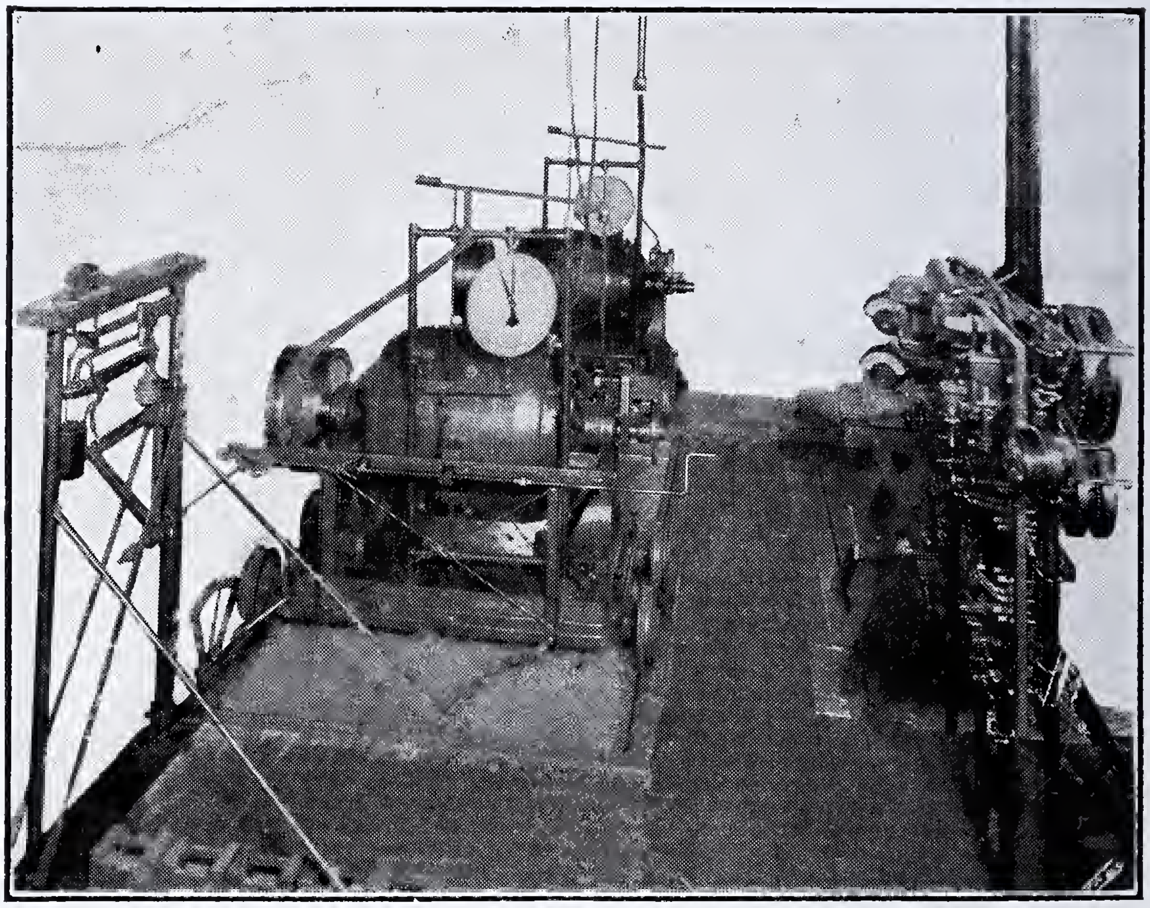

# An Experiment to Determine the Law of Variation Between the Width and Transmitting Capacity of Leather Belting.

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*OBJECT*:

The object of this experiment is to prove whether or not the commonly accepted statement that the transmitting capacity of a leather belt varies directly with the width is true, and if not to determine the correct law of variation between width and transmitting capacity.

*APPARATUS*:

A picture of the apparatus used in these tests is shown on the opposite page. This equipment has been gradually developed by the research engineers of the Leather Belting Exchange until it is now one of the best pieces of apparatus of its kind. The following detailed description is intended for those who are not familiar with this type of testing machine.

The apparatus consists principally of two 100 H. P. electric dynamometers, either of which may be used to drive the other through the test belt. They also may be run in either direction so that the driving side of the belt can be used above or below. One of the machines, which is commonly used as an absorbing dynamometer, is mounted on ball bearing flange wheels, so that it can be very easily rolled along a carefully leveled track to accomodate belts of different lengths. This track also carries a tension weighing mechanism, with a connecting cable to the dynamameter, which holds the dynamometer in place when the belt is on, and transmits the total pull of both sides of the belt to the weighing bar. In addition each dynamometer is equipped with torque scales, which register

total torque, including the bearing friction. From the tension weighing mechanism we can determine the sum of the tensions on the belt, and from the torque reading we can calculate the difference of tensions. With the sum and difference of the tensions known we can obtain either tension.

The machine is equipped with electrically operated techometers and revolution counters from which the R. P. M. is accurately determined. Our slipmeter is a differential counter of the rotating lamp type, which revolves once for each revolution difference in the speed of the driver and the driven. The slip is measured by counting the total revolutions of the driver, with the electric counters, while the light is making a sufficient number of revolutions, to insure accuracy. From these observations the percent slip can be computed by dividing the number of revolutions of the lamp, by the number of revolutions of the driver.

The armature circuits of the two dynamometers, and that of a third machine called the booster, are connected in series with each other, so that the operating current merely circulates through the three machines. The booster is a steam turbine driven generator, and it supplies most of the losses. All three machines are separately excited from a small 220 volt motor generator set, the field strength of each controlled by individual rheostats.

Control of the apparatus is concentrated at the switchboard upon which are mounted the three field rheostats and all main switches, as well as switches for the counters, tachometers and slip-meter.

In operation, the load and speed are entirely regulated by manipulation of the three field rheostats. No starting resistance is necessary, because the terminal voltage at the motor dynamometer can be reduced to a very low value by field control of the booster. No load absorbing resistance is required, because the current from the generating machine is fed back to the driving machine, and our booster has to supply the normal losses in the two dynamometers.

With this apparatus we are able to make belt tests at shaft speeds of from 100 to 1000 R M. P., with a rated capacity of 100 H. P. at 450 R. M. P. During these tests we take measurements of torque, speed, belt slip, total tension, sag of

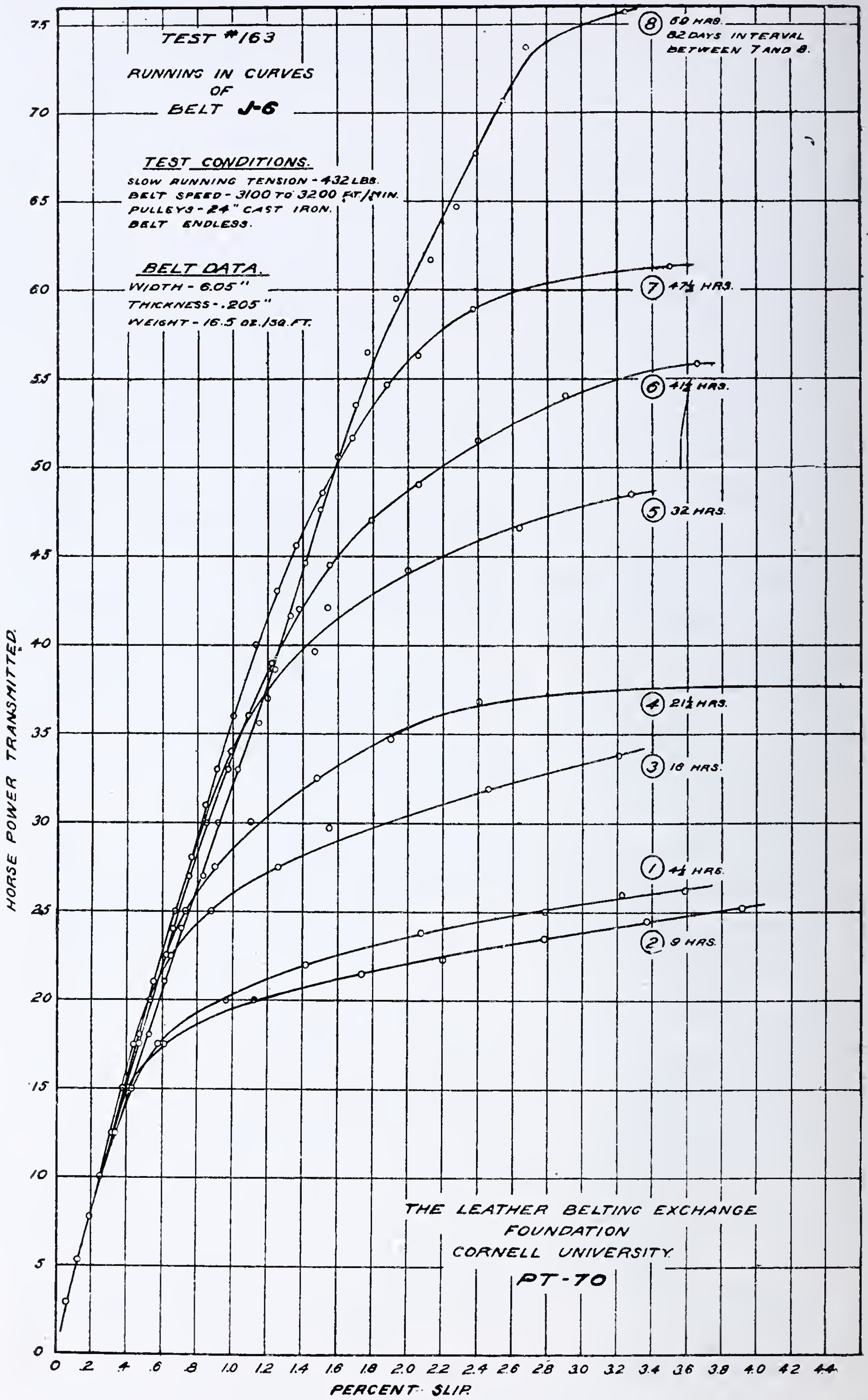
the belt half way between the pulleys, and center distance between the shafts. This latter value is obtained from a special device, which reads any center distance variation to within .005 of an inch. Readings of the temperature and humidity are taken also.

*METHOD OF MAKING TEST*:

The belt J-6 selected for use in this experiment was a first quality single 6.05 inches wide, .205 inches thick, and weighing 16.5 ounces per square foot. A belt speed of 3100 to 3200 feet per minute and a tension of 36 pounds per inch of width in each strand were chosen, because they represent average practice. All tests were run on our standard cast iron pulleys which are 24 inches in diameter with a 10.5 inch face, and which have been carefully balanced to eliminate vibration.

To get the belt into good condition, so it would give consistent results from day to day we started the experiment by running the belt in until little or no improvement was obtained with further rnnning. Each day a capacity test was made to show the improvement. The horse power slip curves obtained during this period are plotted on PT-70, horse power being plotted on the vertical axis, against slip on the horizontal axis. No improvement resulted from the first days run, but after sixteen hours running considerable increase was shown by curve #3. From then on the belt improved each day until test #9, which showed but little improvement over #8. At the highest loads obtained during #8 and #9 the conditions became unsteady and the readings difficult to take due to flap and irregular slippage, so we considered it useless to run the belt in any longer, on a chance of further improvement. Just before test #8 was made, one of the dynamometers had to be shut down for repairs. After completing them the running in was not resumed because of more urgent work. Finally after an interval of 82 days, test #8 was made which showed a big improvement over #7. Eight and one-half hours later #9 was made and the belt was in condition to give reliable results. At this point the experiment was started by cutting

the belt down one inch at a time, and making a test at each width.

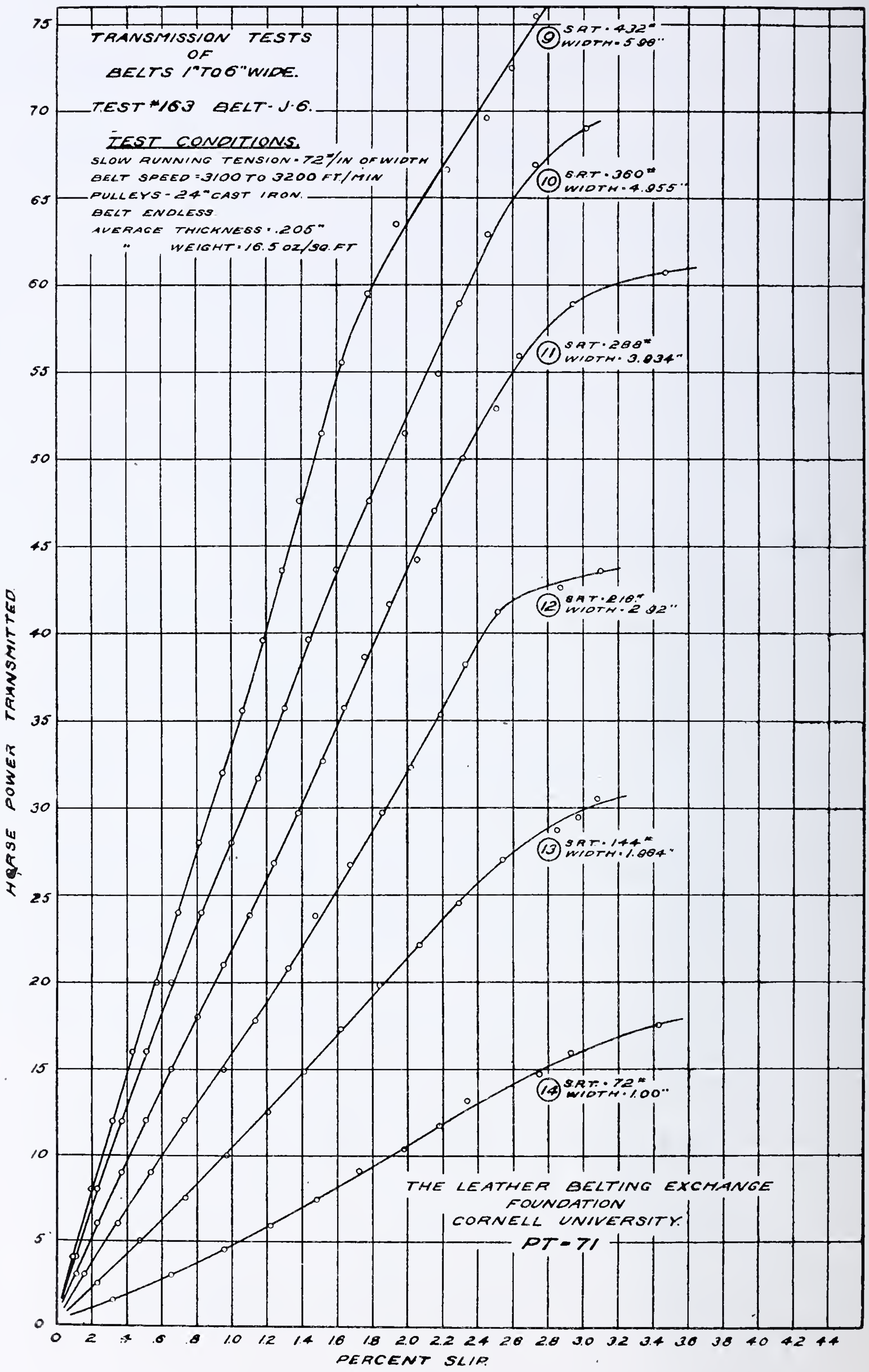


Briefly, the method of running the experiment after the belt had been well run-in, was to test each width from the six inch down to the one inch under the same tension per inch of width, so that the stresses in the belt were about the same for all tests. Thus the total tension applied on both strands of the six inch width, as measured by the scale was $6 \times 2 \times 36 = 432$ pounds. For the other widths this value was reduced in proportion to the reduction in width. We ran tests on each width by increasing the load gradually in increments, and observing the slip, total tension, sag, etc. for each increment of load. These tests, one on each width from six inches down to one inch, give us the basis for our conclusions regarding the effect of width. See PT-71.

Our procedure in applying and maintaining the tension was first to set the tension, when the belt was running very slow, under no load. This tension called the "slow running tension" (S. R. T.) is merely a more accurate method of setting the "standing tension", because the tension obtained is an average of the many positions which the belt can take on the pulley, rather than the result of setting the tension when the pulley and belt are in only one position relative to each other. In order to maintain the tension throughout the test, we reset the slow running tension between each increment of load. We have found that this is the most satisfactory method of running accurate tests, because the belt is under the same tension at all times regardless of temperature and humidity changes. It also neutralizes the slow shrinking or stretching action, due to a previous test.

In cutting down from the six inch width, the one inch strips were cut from alternate sides of the belt so that the last two strips came from the center of the belt. Each belt was carefully measured for width at ten places along its length. The average width is recorded on the curves of PT-71. During this series of tests the relative humidity ranged between 29%

and 36%, except for the five inch width when it was 45%. The room temperature ranged from 70 to 77 degrees.



*DISCUSSION OF RESULTS:*

The horsepower-slip curves, one for each width, as given on PT-71, clearly indicate a regular falling off in capacity as the width is reduced. Our tests on the narrow widths are more accurate and consequently plot a little better because the testing machine was carrying a smaller load in proportion to its capacity. At the high loads, such as 80 horsepower and the accompanying high slippage, the belt flap became troublesome and interfered with accurate setting of the load, so the points are a little irregular at slippages of 2.5% or over.

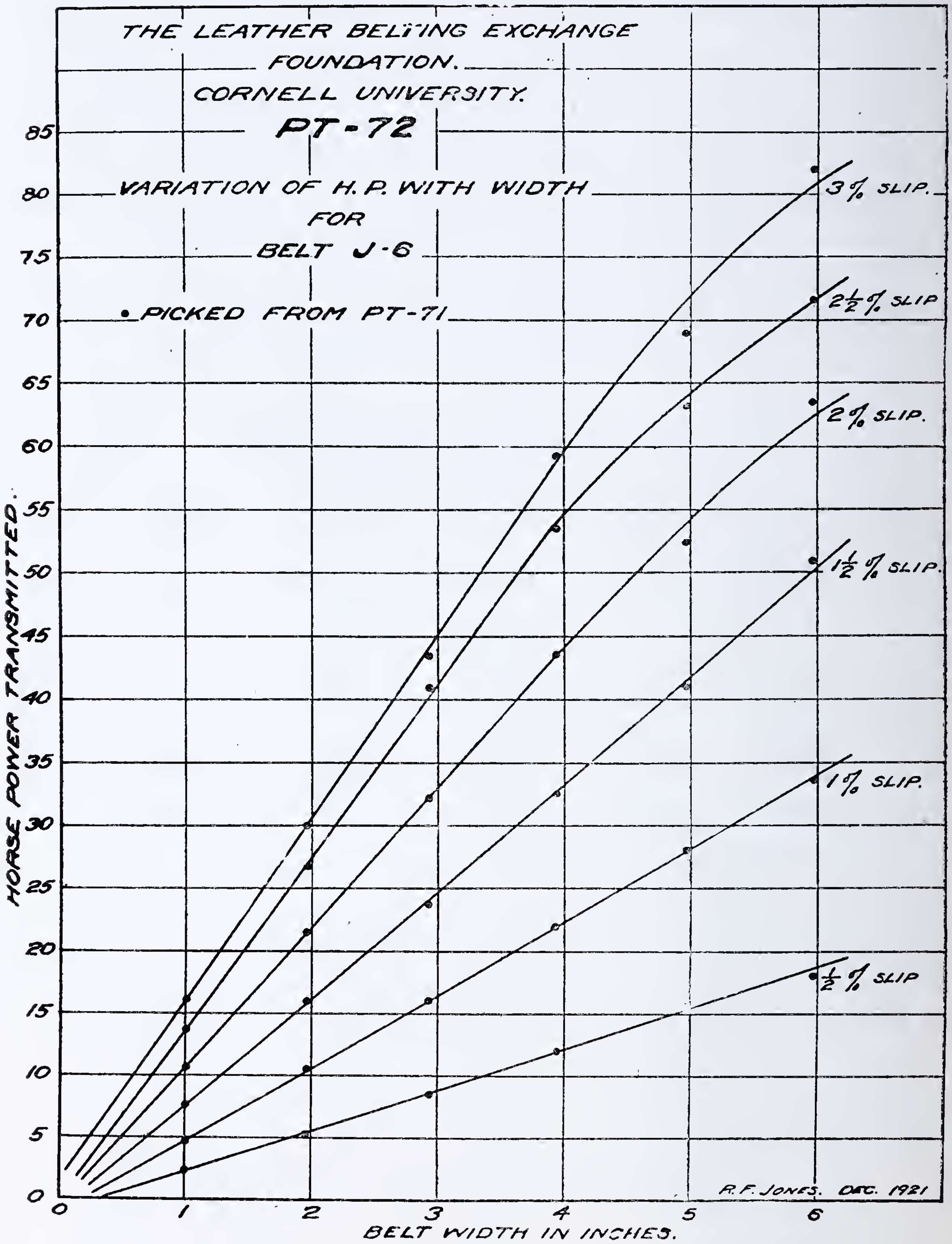
From the curves on PT-71 the following table showing the relation between width and horsepower at slips of .5, 1.0, 1.5, 2.0, 2.5 and 3.0 percent, was constructed.

*TABLE OF H. P. AND WIDTH.*

| % slip | H.P. 1″ width | H.P. 2″ width | H.P. 3″ width | H.P. 4″ width | H.P. 5″ width | H.P. 6″ width |
|---|---|---|---|---|---|---|
| .5 | 2.3 | 5.2 | 8.5 | 11.9 | 15.6 | 18.1 |
| 1.0 | 4.7 | 10.5 | 16.0 | 21.9 | 28.1 | 33.6 |
| 1.5 | 7.6 | 15.9 | 23.7 | 32.5 | 41.0 | 50.9 |
| 2.0 | 10.6 | 21.4 | 32.1 | 43.6 | 52.4 | 63.5 |
| 2.5 | 13.6 | 26.6 | 40.9 | 53.4 | 63.2 | 71.6 |
| 3.0 | 16.0 | 29.9 | 43.3 | 59.3 | 68.9 | 82.0 |

In order to bring out the relation between width and horsepower more clearly the data in the table is plotted on PT-72, horsepower being plotted on the vertical axis and belt width on the horizontal axis. Six curves are obtained, one for each percentage of slip used in the table. Examination of the curves at .5, 1.0 and 1.5% slip disclose the fact that in each case the data lie along a straight line, which proves that the horsepower increases in proportion to the width for slips up to 1.5%. This is not so apparent from the figures in the table, where in some cases the law does not seem to hold true, because of a small zero error in the testing machine, probably due to windage. The straight lines obtained by plotting our results in this way is a true average of the figures in the table, while any comparison of individual data in the table is subject to

a greater experimental error. Thus within 1.5% slip which is the limit of practical operation, the horsepower seems to increase directly with the width.




Above 1½ percent slip the horsepower-width curves bend slightly to the right, which may be due to falling off of horsepower increase with an increase of width beyond 4 inches. A more probable explanation is that at the higher slippages

where the condition of the surface determines the capacity, the belt did better than on the narrower widths, because it had been run longer on these widths. To illustrate, the five inch width belt was in slightly better condition than the six inch, because the running nesessary to test the six inch width improved the surface, and the four inch was better than the five inch for the same reason. This effect would not be apparent below 1½% slip because the slippage up to this point is practically all creep, which is dependent upon the elastic property of the leather, and which would not be affected by small changes in the surface. Another logical reason for this slight curvature is that when the belt is run in a small strip along each edge does not improve like the leather in the middle. Therefore, when a one inch strip is cut from each edge the remaining belt will transmit more power in proportion to its width than the wider belt would. As in the previous case, only the capacity at the higher slips would be affected because it is only at these high slips that a small change in surface would have any effect.

*CONCLUSION*:

1. Within the practical range of design the horsepower varies directly with the width. Therefore, a two inch belt will transmit twice as much power as a one inch belt, a three inch three times as much, etc.

2. Our experiment only covers the range from the one to six inches, but there is no reason to believe that this law does not hold true for all widths.

3. Since the test belt lay idle for 82 days between tests #7 and #8 and yet showed no decrease in capacity, when put back on and tested, we may conclude that the belt retained its very good surface during this period, and therefore any reduction of capacity after replacing a belt is due to stretching with the consequent reduction of tension, rather than to a poorer surface.

4. Another series of tests similar to these would be advisable to check this work on another belt and to more definitely determine the cause of the curvature on the 2, 2½ and 3% curves of PT-72.

Respectfully submitted,

R. F. JONES.

*THE LEATHER BELTING EXCHANGE*
*Philadelphia, Pa.*

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January 19th, 1922

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